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CONTENTS.

How to See Colorado from Boulder 440
Tabulated Recapitulations as a Means of Education. P. A. Cushman. 450
Some Relations of Engineering Education to Engineering Ethics. Thorndike Saville 459
Opportunities for the Young Instructor. Louis Mitchell 467
Organized Discussion on Methods of Teaching at Yale. James Crosby Chapman 471
Colorado Inaugurates a Summer Surveying Camp. Herbert J. Gilkey. 475
The English Department 478
Discussion of the Progress Report of Committee No. 20. Edgar MacNaughton. 480
College Notes 483
Sections and Branches 486
Society Notes 491
British Association for the Advancement of Science 491
International Mathematical Congress 491

HOW TO SEE COLORADO FROM BOULDER.

S. P. E. E. Transportation Committee, University of Colorado—C. L. ECKEL, Chairman, W. F. MALLORY, W. S. BEATTIE, and C. B. ASHCRAFT.

Since many members of the S. P. E. E. have indicated a desire to spend some time in the West after attending the annual meeting at Boulder, the following information concerning points of interest, routes, and fares is presented as an aid in purchasing tickets and in planning railroad and automobile trips. As interesting trips in this region are exceedingly numerous, a description will be given of only a few of the better-known ones.

Railroad Trips from Boulder and Denver.

Some general hints about buying railroad tickets may be helpful. Members who may wish to visit at Colorado Springs or Pueblo, for instance, should inquire of their local agent about purchasing common-point tickets, as most summer excursion trips routed via Denver include a free side trip to either of these points. From Colorado Springs, the trip to Pikes Peak can be conveniently made. To go to Salt Lake City, Los Angles, San Francisco, Yellowstone Park, and other distant points, a considerable financial saving can be effected by purchasing summer tourist tickets to the final destination. These tickets should be routed through Denver with a stop-over at Denver. A side trip may then be made to Boulder, which is only thirty miles northwest, and may be reached by three conveniently scheduled trains over the Colorado and Southern Railroad or by hourly cars over the Denver and Interurban Kite Route.

The Denver and Salt Lake Railroad Company, otherwise known as the Moffat Road, operates trains daily from Denver to Corona, a station on top of the Continental Divide. In addition to the regular service, what is known as the "Scenic

FIG. 1. "The thrill that comes once in a life time" is felt in making the first trip over a high-line drive. This road winds around Flagstaff Mountain, immediately west of Boulder.

Special'' leaves Denver at 8:45 A.M. and returns at 5:45 P.M. The fare from Denver to Corona and return is $5.00; but for parties of ten or more on one ticket, the fare is $4.50 per capita.

If desired by a sufficient number, it will be possible to arrange a special excursion from Boulder to Corona via the Denver and Interurban Kite Route and the Moffat Road. There are many engineering features of interest on the Moffat Road, a special one being the new Moffat Tunnel through the Continental Divide. Work is in progress on the tunnel, which is to be 6.09 miles long, and it will be possible to arrange a special stop of sufficient length of time near the east portal of the tunnel to see actual construction. (It should be noted that a trip to the east portal may be made from Boulder by automobile also.)

The popular Georgetown Loop Trip is made from Denver via the Colorado and Southern Railroad. Trains leave Denver daily at 8:10 A.M., returning in the evening at 5:15 P.M. The round-trip fare is $3.96, with an excursion rate of $2.65 for Sundays only. Points of interest are Golden, the first capital of Colorado, Clear Creek Canon, Idaho Springs, Georgetown, The Loop, and Silver Plume.

Colorado Springs, about 75 miles south of Denver, may be reached by the Denver and Rio Grande Western Railroad, by the Colorado and Southern, or by the Santa Fe. A free side trip to Colorado Springs is included on most summer excursion tickets. Pikes Peak, Cheyenne Mountain, South Cheyenne Canon, Monument Valley Park, the Garden of the Gods, and many other interesting trips may be made from Colorado Springs.

Five miles west of Colorado Springs, at the foot of Pikes Peak, lies Manitou, which is famous for its iron, sulphur, and soda springs. The ascent of Pikes Peak may be made from Manitou by the Cog Road or by automobile.

Pueblo, about 120 miles south of Denver, may be reached by the Denver and Rio Grande Western Railroad, by the Colorado and Southern, or by the Santa Fe. About 45 miles

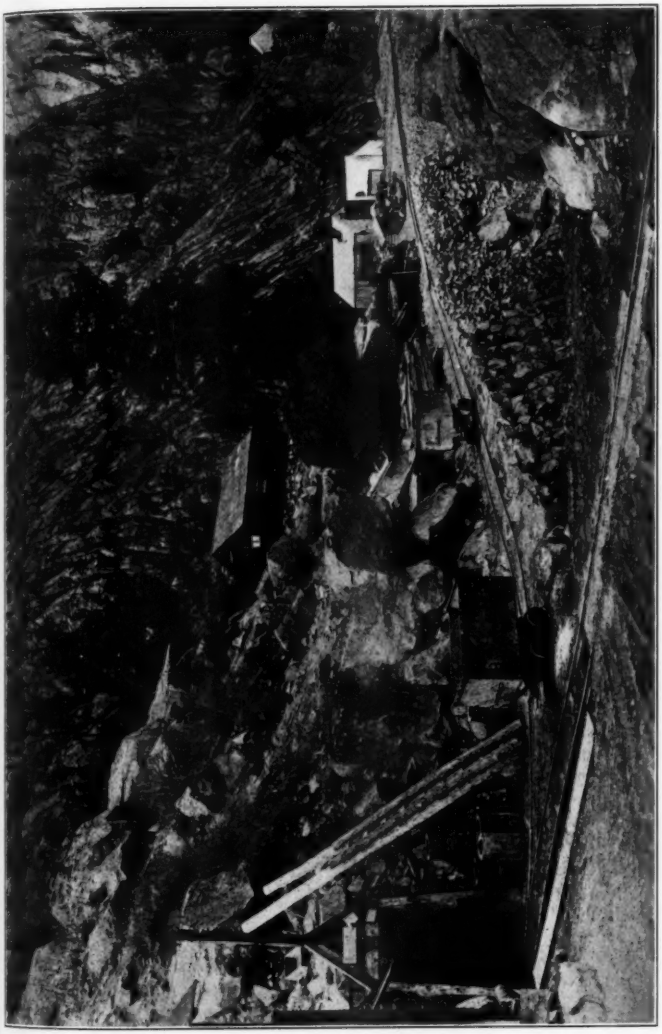

Fig. 2. Entrance to a Tungsten Mine.

west of Pueblo is the entrance to the Royal Gorge, which is of great scenic beauty. Pueblo is usually a common point on tickets to Denver.

If, at the time of purchasing ticket, the request is made for the side trip to Pueblo via the Denver and Rio Grande Western, the Royal Gorge trip may be taken at small additional expense and may be made in one day from Denver.

The trip to Mesa Verde National Park is well worth while if time is available. This trip is made from Denver via the Denver and Rio Grande Western Railroad. There are many prehistoric dwellings in the park, and those which have been cleared of debris may be visited in one day, although a longer stay is desirable. This trip may be made as a part of what is known as "The Around the Circle Trip," which affords a systematic method of viewing the mountain scenery in southern and western Colorado. This trip starts at Denver, Colorado Springs or Pueblo, and returns to the same points. Allowing one day at Mesa Verde Park, the trip may be made from Denver in five days, although it is usually desirable to allow one week's time. The round-trip fare from Denver is $54.95, and from Pueblo the round-trip fare is $41.90.

Automobile Trips from Boulder.

Many scenic mountain trips out of Boulder may be taken by automobile. The routes are through regions of varied and fascinating grandeur; the drivers of the cars are competent; and the time of departure and arrival is scheduled. A few of these trips through the Colorado National Forest and into the Glacier region are as follows:

Top of the World Trip. Fare: $7.50 for each passenger. Cars leave Boulder at 9:00 A.M.; return to Boulder at 6:30 P.M.

This trip goes up Boulder Canon to Nederland, passing the hydro-electric plant of the Colorado Power Company, Boulder Falls, Castle Rock, numerous gold and tungsten mines, and Nederland Dam. From Nederland it goes to Tolland, and then to the east portal of the new Moffat Tunnel. At

FIG. 3. The High-Line Drive between Nederland and Ward on the Road from Boulder to Estes Park.

Tolland the Moffat Railroad is taken to the top of the Continental Divide, which at this point is 11,660 feet in altitude. The return trip to Boulder is over the same route.

Short Glacier Circle Trip. Fare: $6.50 for each passenger. Cars leave Boulder at 9:30 A.M.; return to Boulder at 6:00 P.M.

This trip presents a variety of scenic contrasts. For fourteen miles, from Boulder to Lyons, the route skirts the foothills of the Divide, thus affording a view of the mountain range on one side and of the plains on the other. At Lyons it goes west into the mountains through South St. Vrain Canon to Allen's Park and Peaceful Valley. From this point it proceeds to Ward and Nederland over the Glacier Highline road, a portion of which is a shelf cut along the sides of the mountains. On this part of the trip a view may be had of the St. Vrain and Arapahoe glaciers. From Nederland the route goes down Boulder Canon to Boulder.

Long Glacier Circle Trip. Fare: $8.50 for each passenger. Cars leave Boulder at 8:00 A.M.; return to Boulder at 6:00 P.M.

This trip is similar to the Short Glacier Trip, except that it is extended to take in Estes Park, and that North St. Vrain Canon is used instead of South St. Vrain. The procedure, furthermore, is reversed. The route is up Boulder Canon to Nederland, and then over the Glacier High Line Drive to Ward, Peaceful Valley, Allen's Park, and Estes Park. The return route is through North St. Vrain Canon to Lyons, and back to Boulder along the foothills road.

Long's Peak Glacier Trip. Fare: $7.50 for each passenger. Cars leave Boulder at 8:00 A.M.; return to Boulder at 4:00 P.M.

The Long's Peak Glacier Trip should not be confused with the Long Glacier Circle Trip. The Long's Peak Trip is the shortest one that takes in Estes Park. Its objective is the Long's Peak territory, including Long's Peak Inn, which is

FIG. 4. Big Thompson Canon.

well known all over the country on account of its founder, the late Enos A. Mills. The route is over the foothills road to Lyons; through North St. Vrain Canon to Estes Park and Long's Peak; and back to Boulder by way of Allen's Park, South St. Vrain Canon, and Lyons.

Arapahoe Glacier Trip. Fare: $13.00 for each passenger. Cars leave Boulder at 8:00 A.M. Because of the nature of the trip, the time of returning to Boulder is not definitely scheduled.

This is a combination automobile and horse-back trip to the famous Arapahoe Glacier, where snow and ice abound at all seasons. Cars go from Boulder to University Camp by way of Nederland. From the Camp, which is one of the permanent mountain recreational centers of the University, the trip to the Glacier is completed on horseback. The return trip is over the same route. The Glacier may be reached by hiking, but two days are generally required.

One-Day Trip to Lookout Mountain. Fare: $8.00 for each passenger. On account of the length of the trip, no definite schedule can be announced.

This is a long circle trip that goes up Boulder Canon, passes through Nederland, Rollinsville, Black Hawk, Central City, and Idaho Springs; crosses over Lookout Mountain by way of a fascinating switchback road; and returns to Boulder through Golden and Denver. Of special interest along the route are Black Hawk and Central City, two of the oldest and largest mining towns in Colorado. Together they had a population of 25,000 when Denver was a village of a few log huts. Now they have barely 400 inhabitants. Other attractions are the metal mines, the high-line drive through Virginia Canon from Central City to Idaho Springs, the grave of Buffalo Bill on Lookout Mountain, and the Colorado School of Mines at Golden.

Two-Day Trip to Grand Lake. Fare: $21.00 for each passenger. On account of the length of the trip, no definite schedule can be announced.

The Grand Lake Trip is especially interesting because the route crosses the Continental Divide at two different points and passes for several miles through the rich and undeveloped region of the western slope. The route from Boulder is through Estes Park and over the Continental Divide to Grand Lake by way of the Fall River road, a switchback road up and down the sides of the mountains. It crosses the Divide through Milner Pass, at an altitude of 11,797 feet. To Grand Lake is a one-day's trip. The return route is across Middle Park on the western slope to Frazer, over the Continental Divide by way of Berthoud Pass, over Lookout Mountain to Golden and Denver, and then back to Boulder. Since snow banks and ice will be found on this trip, heavy clothing should be worn.

Many other attractive and desirable auto and train trips may be made from Boulder or Denver. At a later date, every member should receive from the railroads detailed information about train trips. If still more information is desired, address C. L. Eckel, University of Colorado, Boulder, Colorado.

TABULATED RECAPITULATIONS AS A MEANS OF EDUCATION.

BY P. A. CUSHMAN,
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Recapitulations in tabulated form appear to be an undeveloped field for the improvement of technical courses,—for the better presentation in a shorter period of time. My intention is to point out in what ways engineering students would gain by the use of tabular recapitulations during their study of fundamental courses.

A primary reason for the failure of many a college student to grasp the fundamentals of such major engineering subjects as English, Mathematics, Mechanics, Thermodynamics, Electricity, Economics, and Chemistry lies in his inability to conceive the correct scope of the subjects. The student does not see clearly the intent of the subject nor of its various subdivisions; neither does he see correctly the relationship of these parts to each other. Therefore he cannot give an accurate and concise recapitulation of any of the more advanced subjects. In other words, he has not learned the fundamentals nor amply acquired the ability to think for himself. This is often what is meant when we say he has not learned how to study.

Possibly it is too much to expect that the undergraduate should meet this test. Few college instructors can see the scope of their own subjects until they have taught them to as many as a dozen classes. It is only after much experience that a teacher can give a thorough recapitulation of his special branch of engineering theory. This may be the reason for a certain lack of clearness in presentation about which some students complain. Perhaps it is small wonder, therefore, that students fall down at the rate of about ninety per cent., —although most instructors commonly pass a larger percent-

age as a reward of effort, or as an endorsement of the partial exposure of the student to the course in question.

Could not a correctly prepared recapitulation and course synopsis used in conjunction with a text-book supply a much needed service and increase the number of students who learn to think for themselves? The student can not supply this feature himself: it requires too much of his time, and he does not even know when he is right or wrong. The text seldom does, and perhaps can not, meet the need. Many instructors make certain intuitive endeavors along this line, but I think few go far enough.

The object of a recapitulation such as proposed must be clearly kept in mind. It is to teach the student to think more quickly and more accurately, and to show him how to study. The primary means for accomplishing this purpose is provided by the instructor's tabulated one page recapitulation. Clear thinking is then possible because the student has a visible conception of the scope of the subject. An appended synopsis, that is a statement of the method of attack, may also be vital, as it is in the method of attack that the student may be slow or uncertain. A recapitulation and its explanatory outline in combination point out the shortest route of study. One can not learn all knowledge by experience; no more can one afford to spend time summarizing each new branch of engineering theory when a sort of extended table of contents will perform the service,—and do it better because it is accurate.

Possibly some elementary subjects, for instance algebra, do not need recapitulation. There are many thousands of engineers and others who know algebra thoroughly. They learned it without the aid of any direct recapitulation in the course of constant use. The various stunts of algebra have been performed so many times that a proper mental summary of the processes has been formed, but at the expense of much time and effort. The frequency of application of algebra augments its common knowledge. But, advanced subjects cannot receive as much attention and must be acquired more quickly. Consequently, they are learned less thoroughly, do not receive

constant review or other form of mental summarization, and logically should be recapitulated for most effective study.

Consider the recapitulation of Thermodynamics of Gases, which is one of the two parts of the theory of thermodynamics. Exhibit 1, appended hereto, analytically summarizes the theory of gases as presented in the first hundred or so pages of the standard texts. This sheet provides a concrete statement of the subject scope and tabulates the deductions of the text. By a frequent reference to this recapitulation, the student may judge for himself just what is his measure of progress and how many details he has still to study in order to complete the subject. An abbreviated summary such as Exhibit 2 appears in many texts, and may well be used as an added reference during study. However, a suitable recapitulation should be theoretically complete like Exhibit 1, wherein no important deduction in the theory of gases is omitted. In a similar manner there can be given a complete graphical presentation of gases such as appears in Exhibit 3. It is to be particularly noted that the recapitulation is not the well-known synopsis, or summary of important points, but is a tabulation which embodies such information as usually appears in a synopsis. Such a synopsis appended as a further supplement to the book may often facilitate study and prevent undue loss of time in making correct use of the recapitulation. The synopsis simply ties together the text and tabulated summary sheet. The numbering system on Exhibit 2 was intended to refer to such a synopsis in order to stress particularly the reasons of all deductions and the statement of experimental facts. Although Exhibit 1 may answer the further purpose of a sort of handbook to one who has learned the thermodynamics of gases, its primary object is to indicate the scope of the subject during study, beginning even on the first day of the course.

The recapitulation is so arranged that no student could use the information in an unintelligent handbook-engineer fashion. That there is no danger of such a misuse has been proved by written tests given by the author to four classes

within the past year, and also to fourteen previous classes in which the recapitulation was used in part during the development stages. As a matter of fact it is in the very lack of the handbook-engineer's instinct that our engineering students fail. They know detail proofs of parts, but lack appreciation of the whole.

In a similar manner the writer has developed a summary of the thermodynamics of vapors, a task somewhat difficult, but nevertheless very satisfactory in results. However, instead of giving more samples from thermodynamics it is more instructive to consider a branch of mechanics. Exhibit 4 shows an analysis of the theory of linear motion which would considerably aid a student in physics. In the latter exhibit it will be especially noticed how much the subject is simplified by tabulating the complete list of formulæ instead of selecting about three-fourths of the easier ones and leaving the student in wonderment when he happens across one of the more complicated formulæ which is perfectly good for use. The student only begins to see the ease of mechanics when he has the tabulated summary presented to him. He can best learn to summarize for himself when he sees the tabulation accomplished. Much of the mental haze surrounding the subject of mechanics, both elementary and applied, could be cleared up by an extension of this principle of recapitulation. In this subject also, what untold assistance might the tabulated summary provide for review in after years! In a similar manner many other subjects, both technical and non-technical, can be presented with great effectiveness. A striking illustration appears in A. E. Phillips' "Effective Speaking" wherein is presented a tabular summary of the principles of public speaking, a course which is now generally regarded as fundamental to the training of engineers.

With almost any subject, study is more readily accomplished when a tabulated recapitulation has been completed, because from that, the student can work backwards and attempt the deduction of all expressions appearing in the table and thus ascertain the thoroughness with which he has learned

the fundamentals. On this one sheet the student has before him at all times a vivid picture of what is being sought as well as a concise statement of all essential conclusions. A carefully prepared synopsis of the method of study may be helpful in a supplementary way, but it can never provide a complete and vivid picture of the subject, and its ideal use is as a connecting link between the tabulated summary and text. We thus see that a complete tabulated recapitulation is an essential aid to thorough understanding of many engineering courses, that it provides a plan of consistent study, and that it serves a vital need in review whether during student days or thereafter.

APPENDED SHEETS FOR EXAMPLES OF ONE-PAGE TABULATED RECAPITULATIONS.

EXHIBIT 1. Analytical Recapitulation of Thermodynamics of Gases. (Good example.)

EXHIBIT 2. Abbreviated Recapitulation of Thermodynamics of Gases. (Example of unsatisfactory method.)

EXHIBIT 3. Graphical Recapitulation of Thermodynamics of Gases. (Good example in so far as graphs can serve purpose.)

EXHIBIT 4. Analytical Recapitulation of Linear Motion. (Graphical might also be included.)

EXHIBIT 1

ONE PAGE SUMMARY OF THERMODYNAMICS OF GASES: ANALYTICAL

	CONST P	CONST. V	CONST. T	ADIABATIC	GENERAL
Ideal Gas Law	$\frac{V_1}{T_1}=\frac{V_2}{T_2}$ $V_t=V_{32}\left(1+\frac{t_t-32}{492}\right)$	$\frac{P_1}{T_1}=\frac{P_2}{T_2}$ $P_t=P_{32}\left(1+\frac{t_t-32}{492}\right)$	$P_1V_1=P_2V_2$	$\frac{P_1V_1}{T_1}=\frac{P_2V_2}{T_2}$ $PV=wRT$	$\frac{P_1V_1}{T_1}=\frac{P_2V_2}{T_2}$ (1) $PV=wRT$ (2)
Exponential Law	$n=0\quad P_1=P_2$	$n=\infty\quad V_1=V_2$	$n=1$ $P_1V_1=P_2V_2\quad T_1=T_2$	$n=\gamma$ $P_1V_1^{\gamma}=P_2V_2^{\gamma}$	$P_1V_1^n=P_2V_2^n\quad \frac{T_1}{T_2}=\left(\frac{P_1}{P_2}\right)^{\frac{n-1}{n}}=\left(\frac{V_1}{V_2}\right)^{1-n}$
ΔE External Work Done By Gas	$P\int_{V_1}^{V_2}dV$ $P(V_2-V_1)$ $wR(T_2-T_1)$ $w(C_p-C_v)(T_2-T_1)$ *Note:-* If $n=0$ $\frac{P_1V_1-P_2V_2}{n-1}=P(V_2-V_1)$	$\int_{V_1}^{V_2}P\,dV=0$	$\int_{V_1}^{V_2}P\,dV$ $P_1V_1\log_e\frac{V_2}{V_1}$ $wRT_1\log_e\frac{V_2}{V_1}$ $wRT_1\log_e\frac{P_1}{P_2}$ $-wRT_1\log_e\frac{P_2}{P_1}$ etc.	$\int_{V_1}^{V_2}P\,dV$ $\frac{P_1V_1}{\gamma-1}\left[1-\left(\frac{V_1}{V_2}\right)^{\gamma-1}\right]$ $\frac{P_1V_1-P_2V_2}{\gamma-1}$ $\frac{wR(T_1-T_2)}{\gamma-1}$ $w\left(\frac{C_p-C_v}{\gamma-1}\right)(T_1-T_2)$ $w(C_p-R)(T_1-T_2)$* $wC_v(T_1-T_2)$	$\int_{V_1}^{V_2}P\,dV$ $\frac{P_1V_1}{n-1}\left[1-\left(\frac{V_1}{V_2}\right)^{n-1}\right]$ $\frac{P_1V_1-P_2V_2}{n-1}$ $\frac{wR(T_1-T_2)}{n-1}$ $\frac{w(C_p-C_v)(T_1-T_2)}{n-1}$ fr. V_1 to ∞ : $\int_{V_1}^{\infty}P\,dV=\frac{P_1V_1}{n-1}$
$\Delta S+\Delta I=\Delta S$ Internal Work Done On Gas or Intrinsic Heat Added to Gas $\Delta I=0$: Disgregation Energy	$wC_v(T_2-T_1)$ $\frac{P(V_2-V_1)}{\gamma-1}$ $\frac{wR(T_2-T_1)}{\gamma-1}$ $\frac{w(C_p-C_v)(T_2-T_1)}{\gamma-1}$ $w(C_p-R)(T_2-T_1)$*	$wC_v(T_2-T_1)$ $\frac{V(P_2-P_1)}{\gamma-1}$ $\frac{wR(T_2-T_1)}{\gamma-1}$ $\frac{w(C_p-C_v)(T_2-T_1)}{\gamma-1}$ $w(C_p-R)(T_2-T_1)$*	0	$wC_v(T_2-T_1)$ $\Delta S=-\Delta E$ $\frac{P_2V_2-P_1V_1}{\gamma-1}$ $\frac{wR(T_2-T_1)}{\gamma-1}$ $\frac{w(C_p-C_v)(T_2-T_1)}{\gamma-1}$ $w(C_p-R)(T_2-T_1)$*	$wC_v(T_2-T_1)$ $\frac{P_2V_2-P_1V_1}{\gamma-1}$ $\frac{wR(T_2-T_1)}{\gamma-1}$ $\frac{w(C_p-C_v)(T_2-T_1)}{\gamma-1}$ $w(C_p-R)(T_2-T_1)$*
$\Delta Q=\Delta E+\Delta S$ Total Heat Added to Gas	$wC_p(T_2-T_1)$ $wyC_v(T_2-T_1)$ $\frac{\gamma}{\gamma-1}P(V_2-V_1)$	$\Delta Q=\Delta S$ $wC_v(T_2-T_1)$ $\frac{V(P_2-P_1)}{\gamma-1}$ $\frac{wR(T_2-T_1)}{\gamma-1}$ $\frac{w(C_p-C_v)(T_2-T_1)}{\gamma-1}$ $w(C_p-R)(T_2-T_1)$*	$\Delta Q=\Delta E$ $P_1V_1\log_e\frac{V_2}{V_1}$ $wRT_1\log_e\frac{V_2}{V_1}$ $wRT_1\log_e\frac{P_1}{P_2}$ $-wRT_1\log_e\frac{P_2}{P_1}$ etc.	0	$\Delta Q=\Delta E+\Delta S$ $\frac{P_1V_1-P_2V_2}{n-1}+\frac{P_2V_2-P_1V_1}{\gamma-1}$ $\frac{wR(T_1-T_2)}{n-1}+\frac{wR(T_2-T_1)}{\gamma-1}$ $w(T_1-T_2)\left(\frac{\gamma-n}{n-1}\right)\frac{R}{\gamma-1}$ $wC_v\left(\frac{n-\gamma}{n-1}\right)(T_2-T_1)=wC(T_2-T_1)$
$\Delta\phi$ Entropy Change	$w\int_{T_1}^{T_2}\frac{C_p\,dT}{T}$ $wC_p\log_e\frac{T_2}{T_1}$ $wC_p\log_e\frac{V_2}{V_1}$	$w\int_{T_1}^{T_2}\frac{C_v\,dT}{T}$ $wC_v\log_e\frac{T_2}{T_1}$ $wC_v\log_e\frac{P_2}{P_1}$	$\frac{P_1V_1}{T_1}\log_e\frac{V_2}{V_1}$ $wR\log_e\frac{V_2}{V_1}$ $w(C_p-C_v)\log_e\frac{P_1}{P_2}$	0	$w\int_{T_1}^{T_2}\frac{\Delta Q}{T}=\int_{T_1}^{T_2}\frac{wC\,dT}{T}$ $wC_v\log_e\frac{T_2}{T_1}+w(C_p-C_v)\log_e\frac{V_2}{V_1}$ $wC_p\log_e\frac{T_2}{T_1}+w(C_p-C_v)\log_e\frac{P_1}{P_2}$ $wC_v\log_e\frac{T_2}{T_1}+wC_p\log_e\frac{V_2}{V_1}$ $wC_v\frac{n-\gamma}{n-1}\log_e\frac{T_2}{T_1}$

Nomenclature

P = lb. per sq. ft.
V = cu. ft.
T = degrees Abs. (F)
t = degrees F
C_p = Sp. heat at const. P
C_v = Sp. heat at const. V
w = pounds of gas
n = exponential constant
Subscript 1 = initial state
Subscript 2 = final state

Units

*Units differ. Divide R by 778, or multiply C_p and C_v by 778.
Unstarred expressions containing P or R give answer in ft. lb. (Entropy in ft. lb./°Abs.)
Unstarred expressions containing C_p or C_v give answer in Btu. (Entropy in Btu./°Abs.)

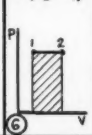
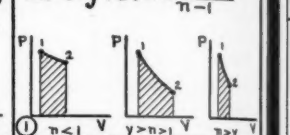
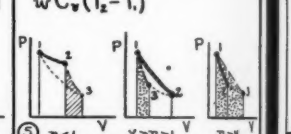
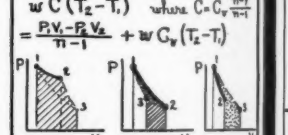
Formulae and Values

C_p = .2375 Btu. for air
C_v = .1689 Btu. for air
R = 53.35 ft. lb for air
$R=C_p-C_v$ *
$R=\Delta E$ for 1° change at const. P
$\gamma=C_p/C_v$
$C_v=R/(\gamma-1)$ *
$C=C_v\frac{n-\gamma}{n-1}$
$n=\frac{\log P_1-\log P_2}{\log V_2-\log V_1}$

EXHIBIT 2

CONDENSED SUMMARY OF THERMODYNAMICS OF GASES

This sheet gives the principal formulae that should be memorized.

	Const. P	Const. V	Const T	Adiabatic	General
Perfect Gas Law	$\frac{V_1}{T_1}=\frac{V_2}{T_2}$ (Charles)	$\frac{P_1}{T_1}=\frac{P_2}{T_2}$ (Charles)	$P_1V_1=P_2V_2$ (Boyle)	$\frac{P_1V_1}{T_1}=\frac{P_2V_2}{T_2}$ $=wR$	$\frac{P_1V_1}{T_1}=\frac{P_2V_2}{T_2}=wR$
Exponential Law	$n=0$ $P_1=P_2$	$n=\infty$ $V_1=V_2$	$n=1$ $P_1V_1=P_2V_2$	$n=\gamma$ by proof $P_1V_1^{\gamma}=P_2V_2^{\gamma}$	$P_1V_1^n=P_2V_2^n$ $\frac{T_1}{T_2}=\left(\frac{P_1}{P_2}\right)^{\frac{n-1}{n}}=\left(\frac{V_2}{V_1}\right)^{n-1}$
ΔE External Work Done By Gas	$P(V_2-V_1)$  ⑥	Zero ②	$P_1V_1\log_e\frac{V_2}{V_1}$ ⑨	$w C_v(T_1-T_2)$ $=\frac{P_1V_1-P_2V_2}{\gamma-1}$ ⑬	$\Sigma FS=\int P\,dV=\frac{P_1V_1-P_2V_2}{n-1}$  ① $n<1$ $\gamma>n>1$ $n>\gamma$
ΔS Internal Work Done On Gas ($\Delta I=0$)	$wC_v(T_2-T_1)$ ⑦	$wC_v(T_2-T_1)$ ③	Zero ⑩	$wC_v(T_2-T_1)$ ⑫	$wC_v(T_2-T_1)$  ⑤ $n<1$ $\gamma>n>1$ $n>\gamma$
$\Delta Q=\Delta E+\Delta S$ Total Heat Added To Gas	$wC_p(T_2-T_1)$ ⑧	$wC_v(T_2-T_1)$ ④	$P_1V_1\log_e\frac{V_2}{V_1}$ ⑪	Zero ⑭	$wC(T_2-T_1)$ where $C=C_v\frac{n-\gamma}{n-1}$ $=\frac{P_1V_1-P_2V_2}{n-1}+wC_v(T_2-T_1)$  ⑮ $n<1$ $\gamma>n>1$ $n>\gamma$
$\Delta\Phi$ Gain In Entropy Reversible Change	$wC_p\log_e\frac{T_2}{T_1}$ ⑯	$wC_v\log_e\frac{T_2}{T_1}$ ⑰	$wR\log_e\frac{V_2}{V_1}$ ⑱	Zero ⑲	$\int\frac{dQ}{T}$ results in four long equations. See 1st Page. ⑳

Speckled areas indicate negative values, for change in direction shown.

P_1 = initial pressure; lb. per sq. ft.

P_2 = final pressure; lb per sq. ft.

V_1 = initial volume; cu. ft.

V_2 = final volume; cu. ft.

dV = change of volume; cu. ft.

n = exponent of exponential curve

w = pounds of gas

T_1 = initial Temperature; °F absolute

T_2 = final Temperature; °F absolute

R = constant of Perfect Gas Law; ft. lb. units

$R=\Delta E$ to raise 1 lb. of gas 1°F at const. P by proof

$R=C_p-C_v$ by proof: $R=53.35=778\{.2375-.1689\}$ for air

C_p = specific heat of gas at constant pressure = .2375 for air

C_v = specific heat of gas at constant volume = .1689 for air

C = specific heat of gas for general case

$=C_v\frac{n-\gamma}{n-1}$ by proof

$\gamma=\frac{C_p}{C_v}$ by definition

indicates isothermal

indicates adiabatic

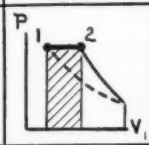
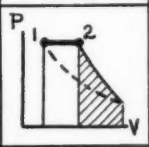
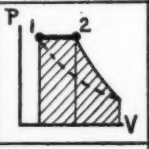
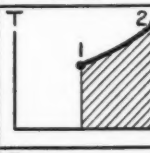
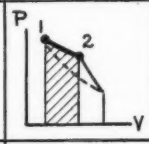
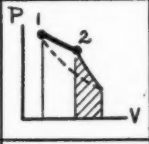
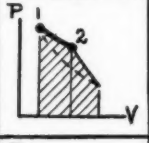
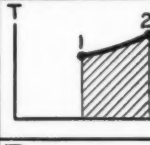
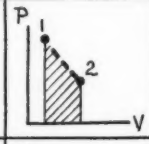
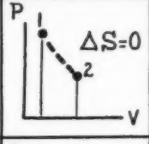
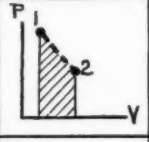
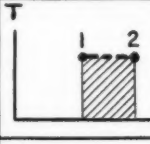
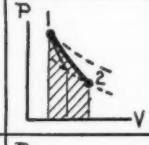
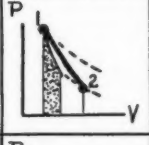
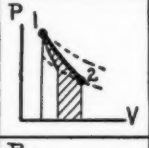
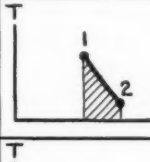
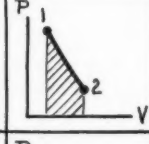
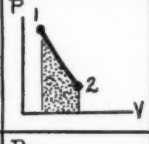
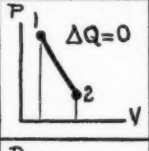
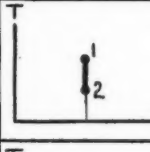
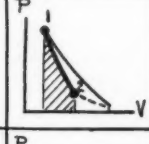
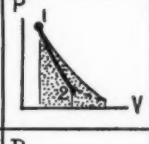
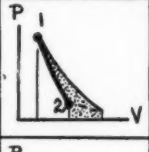
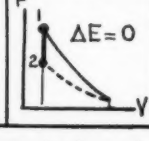
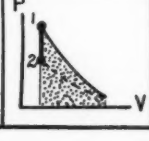
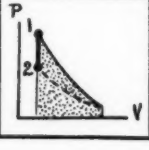
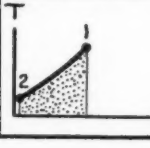
Units of Answers for	$\Delta E, \Delta S, \Delta Q$	$\Delta\Phi$
Terms containing P or R	ft. lb.	ft. lb/°Abs.
Terms containing C_p or C_v	Btu.	Btu./° Abs.

Expressions containing P or R and C_p or C_v must have all terms converted to same units.

EXHIBIT 3

ONE PAGE SUMMARY OF THERMODYNAMICS OF GASES: GRAPHICAL

Arranged in Order of Increasing Values of n,
the exponent of $P_1 V_1^n = P_2 V_2^n$

	ΔE	ΔS	ΔQ	ΔQ
$n=0$				
$n<1$				
$n=1$				
$1<n<y$				
$n=y$				
$n>y$				
$n=\infty$				

----- Indicates isothermal

—— Indicates adiabatic

Indicates change under consideration

Indicates positive numerical results for change in direction shown

Indicates negative numerical results for change in direction shown

Reversal in direction of any of above changes reverses sign of $\Delta E, \Delta S, \Delta Q$.

EXHIBIT 4

Analytical Recapitulation of Linear Motion

Formulae for Dynamics of Body Uniformly Accelerating from v_1 to v_2

v_2(ft.p.s.)	v_1(ft.p.s.)	a(ft.p.s.p.s.)	s(ft.)	t(sec.)
$v_1 + at$	$v_2 - at$	$\frac{v_2 - v_1}{t}$	$v_1 t + \frac{1}{2}at^2$	$\frac{v_2 - v_1}{a}$
$\frac{s}{t} + \frac{1}{2}at$	$\frac{s}{t} - \frac{1}{2}at$	$\frac{2v_2}{t} - \frac{2s}{t^2}$	$v_2 t - \frac{1}{2}at^2$	$\frac{v_2 - \sqrt{v_2^2 - 2as}}{a}$
$\sqrt{v_1^2 + 2as}$	$\sqrt{v_2^2 - 2as}$	$\frac{v_2^2 - v_1^2}{2s}$	$\frac{v_2^2 - v_1^2}{2a}$	$\frac{-v_1 + \sqrt{v_1^2 + 2as}}{a}$
$\frac{2s}{t} - v_1$	$\frac{2s}{t} - v_2$	$\frac{2s}{t^2} - \frac{2v_1}{t}$	$\frac{1}{2}(v_1 + v_2)t$	$\frac{2s}{v_2 + v_1}$
Final velocity	Initial velocity	Uniform acceleration	Distance at end of t seconds	Time of acceleration

Since $F = ma$ the above values of a may be multiplied by m to thereby obtain four equations for F.

The value F/m may be substituted for a in any of the expressions appearing in the table.

The expressions apply without change of notation for retarded motion, since in that case both F and a are negative.

SOME RELATIONS OF ENGINEERING EDUCATION TO ENGINEERING ETHICS.*

BY THORNDIKE SAVILLE,

Associate Professor of Hydraulic and Sanitary Engineering, University of North Carolina.

The principal concern of a state Engineering Society may well be to *maintain the Engineering Profession on an equal status with those of law and medicine, and to increase its prestige.* This is difficult under any circumstances, though not, as is sometimes asserted, because engineering is a younger profession, for engineering is of equal or greater antiquity than other professions. One has only to consider the works of the Medes and Persians, of the Ptolemies in Egypt, of the Greeks and Romans in Europe, and of the Aztecs in South America, to realize that the great civilizations of the past are remembered by the buildings, water supplies, aqueducts and bridges of their engineers and architects, equally with the work of their lawmakers and physicians. The art of engineering was ahead of the science of engineering in these days, but even so, it was probably further developed at the time than the more technical aspects of either law or medicine. The present difficulty in maintaining the professions of engineering upon a party with other learned professions seems basically to be two-fold:

1. Because there is usually a four year undergraduate course to prepare for engineering, as compared to a six or eight year course in medicine and law. We cannot expect, under these circumstances, the "run of the profession" to get an even start with lawyers and doctors who have a general academic course prior to their technical training, and so are better fitted to cope with public questions. They have a

* Address at the Annual Convention, N. C. Society of Engineers, Asheville, N. C., August, 1923.

greater knowledge of a background which covers history, language, and political science, than does the young engineer.

2. Because the engineer is often more closely and directly allied to industry than the other professions. The demarcation between the professional engineer and the member of an engineering organization devoted largely to the business of constructing and financing is difficult to determine. In such lines of work, the engineer loses his professional status, or has it confused in the public mind.

In some states, especially in the South these two normal handicaps upon equal recognition of the engineer are more than ordinarily difficult, from further causes:

3. Industrial growth in these states in the past decade has been so great that public and private construction upon which engineering employment largely depends, has expanded beyond the capacity of local state engineering talent to cope with.

4. A lack of adequate engineering schools of high calibre in these states until recent years.

These last two factors are well illustrated by conditions in North Carolina. Most of the principal consulting engineers in the state, and those in responsible charge of major state and private work, are not North Carolinians born, but come to the state after receiving their education and acquiring their professional ideals elsewhere. They are of diverse antecedents and lack a local state background. I do not wish to imply at all that these engineers are not altogether fit to be leaders in engineering thought in any state, but in every state there is a need of a body of engineers reared and trained in that state, and the need of building up there a professional engineering *esprit de corps* similar to that which binds together the lawyers and doctors. I could cite definite evils which have resulted from the highly individual organizations built up by different engineers in such states, all competing keenly for the rather limited amount of work available until recently, and lacking a bond of professional consciousness to bind them together. The evils are apparent,

however, and the problem is how to better things in the future.

I have stated that the first concern of a non-technical state engineering society may well be to raise and maintain the standards and to increase the prestige of the engineering profession in the state. We must do the first before we can think of attempting the second.

We cannot do it by establishing rules of ethics, though these are helpful, for the unscrupulous will always break them. Thus, rules of ethics do not stop an unscrupulous engineer from deliberately increasing the amount of work to be done over that necessary, in order to gain a larger percentage fee on the increased cost.

We cannot do it by agreements, such as those which have been suggested to fix prices for engineering services to prevent price-cutting, for the unscrupulous will do things like this, and an engineer entering such an agreement makes a tantamount admission that he might cut prices without it.

We cannot raise standards by legislating or acting in concert to raise the salaries of engineers, for by and large the "laborer is worthy of his hire" in engineering as in other professions, which have not found it necessary to adopt such practices.

A *professional standard must be built up within the profession itself—not an artificial thing of rules and agreements, but a professional consciousness.* This is what the lawyers and doctors have done, and is a partial result of their post-graduate study in professional work.

There will be shysters in every profession, but this cannot hurt the legitimate practitioner if the whole body of opinion of the profession is against shysters' practices. Take for example price cutting, charged in several states in recent years. If the professional engineering group in the state is a unit against it, if they have a professional consciousness definitely opposed to price cutting, or to any other breach of professional ethics, two things follow:

1. The sentiment is such that a price cutting engineer

cannot hold up his head in a gathering of his fellows, and eventually their attitude will be reflected in a loss of public confidence and decrease in work, and

2. Clients getting cut prices always get a cheap job, and eventually turn to other engineers. A good engineer cannot cut prices and do high grade professional work. Yet all cannot be high class engineers and charge the highest fees. There is work for all. We must distinguish between high fees proper to the ablest engineers, lower fees proper to less experienced or less able engineers, and cut prices. Because a less experienced engineer adopts a fee schedule lower than that of the best engineers in the state he is not cutting prices, and the high grade, high fee engineer has no moral right to complain if clients wish the less experienced man at the lower price. In general, in engineering as in every other walk of life where services are sold, a man eventually gets about what his services are worth. If prices for work are boosted to a set scale, there will be resulting poor work from the less capable engineers; work worth a small fee, but not the fee set. The result is a lack of public confidence, and loss in prestige to the profession. High grade doctors are not disturbed by quacks, nor high grade lawyers by ambulance chasers. Good work and ability in engineering bring clients and high fees just as in any other line of endeavor, and they cannot be secured in any other way.

The standards of the engineering profession can be raised only from the very foundation upward, particularly in those states where engineering work has recently increased rapidly. When they are raised the prestige due the profession will surely follow. To beget the professional class consciousness necessary to bring engineering in these states to a par with the other learned professions, the following principal lines of endeavor are suggested:

1. *Proper Professional Education in the State.*—This will build up a body of engineers with the tradition of a common background a technical education adequate to fit them for any responsibility; and a fellowship and understanding that can

only come from association during the formative years of their professional preparation giving these things, a group of young engineers results with the same ideals, the same aims, and similar outlook upon the problems of the state. Grant this, and you have produced the backbone of a real engineering profession in the state.

In North Carolina the conditions adverse to the establishment of a proper professional attitude have been about as difficult as anywhere. It is pleasant to be able to state that the first step toward betterment is now assured to the profession in this state. At the Engineering Schools of the University and of the State College, during the past few years there have been developed curricula and standards equal to those of any similar places in the country. At the University there has been introduced the cooperative course in engineering, whereby the student in the third year spends a large amount of time at work in engineering or industrial practice, not as instrument man or foreman, but as laborer, from setter, tracer, meter tester, filter plant operator, etc. Thus he learns certain of the more important practical aspects of work he is later to supervise, and gains a valuable and vital touch with labor. He has only one month vacation in the second and third years, instead of three months formerly granted. The students work in pairs, one being "on the job," while the other is attending classes. The intervals are ordinarily from four to six weeks and a job is thus always manned. The employers of engineers in this and adjoining states have received the new plan most enthusiastically, and the demand for student-workers is far greater than the supply. The saving in time by reducing the length of vacations in the sophomore year (where surveying is given at a summer camp) and in the junior year, enable the courses to be far more replete with the "arts" subjects than heretofore. Language, history, public speaking, political science, business administration, etc., are given in addition to technical instruction, to make the graduate fit to take up the responsibilities of a citizen, as well as those

of an engineer. In equipment, the University ranks second to none in the south, and surpasses most. We encourage our promising young men to return for graduate study, and by means of fellowships are able to attract to our graduate courses able men from other colleges in the south. The valuable research work done by our graduate students in coöperation with the State Highway Commission has already been brought to your attention by the State Highway Engineer. Smiliar work along other lines is being constantly carried on with the State Board of Health and State Geological and Economic Survey, resulting in advance in engineering art, or the collection of engineering data of very definite value to the industrial progress of the state.

In short, the Engineering School of the University is at present functioning as a real School of Engineering, and turning out graduates trained in the best way that is known, and able to compete well with those trained elsewhere. As a result, we find our graduates in demand for positions of real responsibility, and hereafter the state will not find it necessary to import its engineers to take charge of important work.

I have spoken at length of the work at the University, because I know of it, and of the spirit to serve the state in the person of the young engineers it turns out, which is in the mind of every one of the faculty. At the State College of Agriculture and Engineering, there exists a like spirit, and it is providing similar training in those branches of engineering allied to agriculture, the textile industry and the mechanical arts.

II. Whenever a state starts on the road to building up a corps of engineers with proper educational preparation and background, as is being done in North Carolina, then the non-technical engineering society should step in to take up the task of raising the standards and prestige of the profession. Its functions are

1. To keep in touch with the Engineering Schools, that their students may hear and know the leaders in the pro-

fession; may learn what progress the state is making along engineering paths; and hear of the relation of engineering to citizenship. The Society should see to it that the Schools keep abreast of the demands, fitting their graduates for the peculiar problems inherent to the state. Upon the product of the Engineering Schools depends the future of the profession in any state, and yet, how much interest as a Society or as individuals have most state engineering organizations taken in them? What do they know of the work the Engineering Schools are trying to do, often under serious handicaps? What do they know of the adequacy of their equipment? What do they know of their deficiencies or advantages? How can they expect the young engineer to be interested in the Society or the profession if they are not interested in him?

2. To furnish a common meeting place, or places, where young engineers after graduation, can keep in touch with one another; talk over difficulties and animosities likely to occur among any group engaged in more or less competitive work, and unable to get each other's point of view by personal association; and keep warm the bonds of friendship built up in undergraduate days. These may be provided by frequent sectional meetings, opportunities for the younger engineers to meet the older; for them to become better known among their profession; and to build up a spirit of loyalty to the profession, not to self.

3. To provide a vehicle of expression for a unified opinion by the engineering profession of the state upon public matters of an engineering nature, or touching upon the profession, or affecting engineering positions in the public service. Cannot the Society voice the thought of the engineering profession, through committees or otherwise, upon such matters of vital interest to the state, as Inland Waterways and Ports, Highways, Drainage of Land and Land Reclamation, Water Power, Flood Control, Topographic Mapping, Forest Preservation, and Engineering Education? All of these are matters in

which the State, *per se*, is interested, and upon which the voice of the profession might well be heard.

4. In short, to contribute as a body to the service of the state, and not the service of self: to encourage its members to take part in public affairs, making a contribution to the public weal, long the sole prerogative of the physician and lawyer.

III. To effect all this, the following suggestions are offered:

1. An organization with sufficient flexibility in its admission requirements to admit any graduate engineer to membership. Certainly all licensed engineers should be eligible, and membership on their part might be automatic upon the payment of a small addition to the license fee.

2. Sectional divisions, in a large state, with frequent meetings, largely social, or dealing with public questions. Technical papers should, as a rule, be avoided.

3. Affiliation with technical engineering societies in the state, such as the A. S. M. E., A. S. C. E., A. I. E. E., etc., and encouragement of the younger members as they become eligible, to join the higher technical societies. Such affiliation is well exemplified by the Engineers Club of Philadelphia and by the Affiliated Technical Societies of Boston.

4. An Employment Bureau maintained jointly by the affiliated state engineering societies.

If all these things are done, honestly and without suspicion as to motive, I am confident we can get the unity in the profession in any state which we all desire.

Just two essentials are necessary for this result, and they have formed the tenor of my remarks. The first is: as a profession, be concerned with the training and early professional life of the young engineer. The second is: build up a professional consciousness among the engineers in the state.

OPPORTUNITIES FOR THE YOUNG INSTRUCTOR.

BY LOUIS MITCHELL,

Dean of College of Applied Science, Syracuse University.

Teaching is a business in which a young man may loaf along for several years without realizing the many opportunities offered for self-development and service to the college and community of which he is a part.

The young instructor in engineering, especially if he has had any previous industrial or commercial experience, is at once impressed with the liberty he is given and the amount of time available which he may use to personal advantage or otherwise as he chooses. Unfortunately, there is usually not the check up or means of showing results in teaching as in industry, and it takes a longer time to see whether or not a man is going to become a valuable member of the College organization.

If we assume that the employment of any instructor presupposes the possession of training, experience and qualifications that enable him properly to conduct his classes or laboratory exercises, and that he will devote to study and self improvement in a professional way, we have simply laid out what is common ground for all teachers.

But the young instructor who is alert and ambitious will not be content to be submerged entirely in his teaching duties. He will spend his summers in such employment as will aid his professional advancement and in addition to his teaching duties will accept such engineering engagements as do not interfere with his school work and are not obtained by a violation of professional ethics. But aside from the things which are so directly related to his duties in the class room there are other avenues through which he may travel.

The college faculty, to operate smoothly and efficiently, must must of necessity consist of men of various talents and abilities, each doing a special part, each contributing some special

service which he can do better than another. The young instructor during his try-out period of service will soon discover he has special adaptation for certain things and not for others. That he has certain natural qualifications but not others and it will be upon his own choice whether or not he makes use of the opportunties offered.

For any college to operate effectively, there must me a harmonious relationship between the student body and the faculty. A review of the latter group in any college will reveal that only certain men have the tact or ability to deal directly with the students, other than in the class room, and gain their sympathy or support. Only certain men, for example, can successfully present a proposition at a student mass meeting, and get cheerful support, especially if the measure is not one which is in popular favor. Other men, although they may be excellent and valuable teachers because of other qualifications, would instantly make a mess of such a situation.

Only certain men can successfully preside at a banquet or deliver an informal talk. For others it would be bore to speaker and audience. This ability to speak effectively in public is a gift, whether it be developed or undeveloped, and makes its possessor a more valuable member of the teaching staff. The young instructor, due to his recent association with student life, will have abundant opportunity to appear at student gatherings. If he has any inclination or ability as a speaker he should strive to develop it, and overcome any natural timidity he may feel. There is no doubt but that this association and relationship between students and faculty goes a long way toward maintaining a strong bond of sympathy and coöperation between the two groups which is separate from the personal satisfaction such association brings.

The administration of college affairs is usually assisted by committees from the teaching staff. Any teacher can go over the list of his associates and pick out men who are good at committee work and those who are poor. The successful operation of the college machinery is dependent upon the

work of these committees. It is work which has a strong appeal to some and is very irksome to others, with the result that these duties usually devolve upon the ones who possess the particular talent to do this work in a satisfactory manner. Here again the young instructor will get his try-out. If this work appeals to him and he does it well, developing a reputation for thoroughness and dependability, he will soon find that additional responsibilities are placed upon him and he thereby becomes a more valuable man.

There are certain men on every faculty that are the "outside men." These are usually, but not always, men mature and experienced. From this group are called the speakers at alumni and social meetings and at the technical clubs. They must have the qualifications of good public speakers, good mixers, as well as established professional ability. These individuals are a very valuable asset to the college, because through them a direct contact is made with the public, especially in their immediate vicinity, and through them oftentimes the character or good name of the college is established. The attainment of this goal is certainly a worthy aim for any young instructor, and one which will widen his personal acquaintance and undoubtedly be the means of incidentally adding to his professional advancement.

Not everyone has the ability to write a book, or technical and semi-technical articles. Many teachers, however, have outstanding ability and bring prestige to themselves and their college when they may score low in other lines. Here is another opportunity for the young instructor. He may prepare notes and texts to be first used in mimeographed form and gradually worked into book form. He may prepare articles and submit them for publication in the technical magazines or the local papers. Even if rejected the experience gained is of considerable value and certainly the field for literary effort is very wide.

Active participation in the local technical society, if one is conveniently near at hand, is an excellent means for extending acquaintance as well as acquiring experience in

public speaking, general information and instruction. Very often the membership of such organizations look to the college faculty to supply the leaders in the society organization. If the young instructor has any talent in this work and becomes acquainted he will find that such offices will readily seek him out and give him a chance to develop new powers. A similar opportunity is offered through church membership and attendance with still a wider field for usefulness and service in the various branches of the church activities. The young instructor in any community starts off with a certain advantage of social prestige and advantage. He has a clear field before him in the college and community life, and a chance to develop generally such as is not offered to the men in any other profession.

ORGANIZED DISCUSSIONS ON METHODS OF TEACHING AT YALE.

BY THOMAS K. HENDRICK,
Secretary, Yale Branch S. P. E. E.

The Yale Branch of the Society for the Promotion of Engineering Education conducted a series of six weekly discussions on the general subject of "Procedure in College Teaching." These discussions were led by James Crosby Chapman, Ph.D., Sc.D., Associate Professor of Educational Psychology in Yale University and were attended by an average of twenty members of the Yale Engineering Faculty.

The first discussion considered the "Mechanism of the Learner." The adjustment of the student to new situations, the making of connections, the obtaining of responses, together with the laws of habit formation and memory were the topics emphasized. The law of satisfaction should be made to operate for a definite objective. The distribution factor in learning should be given careful consideration. The revision of material, the methods of recall, the emphasizing of strategic points are especially important in obtaining permanent connections.

The second, third, and fourth discussions came under the general heading, "The Teacher as an Instructional Guide."

The second discussion considered the teacher as a stimulator of the learner's mechanism. The average undergraduate student does not go to class with the intent of doing strenuous thinking. By presenting material from the standpoint of the problem method so that a student has to arrive at conclusions through difficulties, the thought process is brought into action. Thus, a student strengthens his tendency to maintain a certain direction, his capacity to make adjustments and the power of self-criticism. Organization and revision of the subject matter is a necessary by-product. An initial clear

statement of the problem serves to maintain the objective and prevents irrelevancy.

In the third discussion, the necessity of having younger college teachers given an opportunity to witness other teachers and to be watched in their own teaching was pointed out. As a guide the young teacher might well consider Herbart's five aspects *: (1) Preparation; (2) presentation; (3) association; (4) generalization; and (5) application. Preparation crystallizes the problem. Presentation gives the solution. Emphasis on relative values, weaving in the old with the new, reduction to a resumé, facility in attacking a new situation are points which require insight and thought on the part of the teacher. In evaluating his own achievement the teacher should ask himself such questions as: Was the problem worth while? Was it of sufficient importance? Was it clear? Was the solution successful? Was it introduced with a wealth of association? Was it applied? Was it released from its narrow settings? Does the individual have a chance to think with respect to the various relationships involved?

That interest in a subject has enormous potency as a stimulator of effort on the part of a student was presented in the fourth discussion. To aid his purpose the teacher uses different methods. These are : (1) lectures; (2) developmental or discussion; (3) combination of lectures and developmental in discussion; (4) student reports; (5) laboratory. The place of each was considered with emphasis on the discussional procedure. A teacher should formulate his own rules for conducting a recitation. Some are here given:

1. Vary methods from recitation to recitation to maintain interest.
2. Don't call on students in regular order.
3. Always state question first—allow time to elapse—then call on student.
4. Give definite question.

* See "Principles of Education," Chapman and Counts, Houghton, Mifflin and Co.

5. Don't repeat question.
6. Don't have any compunction about squelching irrelevant discussion.
7. In case of long answer—occasionally have student break off and have another student continue.
8. Commend and blame students.
9. To emphasize a difficulty, it may sometimes pay to lead students into fallacious arguments.
10. Set definite task and stimulate competition.
11. Use blackboard freely.
12. Avoid letting a student monopolize too much time.
13. Don't leave assignment to be given hastily at close of recitation.
14. Don't use recitation period for quizzing on factional material. The recitation should be used for developing problems, making applications, and clearing up difficulties.

The fifth and sixth discussions took up the "Classification and Grading of Students."

In the fifth discussion, the necessity of evaluating the student was brought out. The creation of incentive is the most urgent reason. The keeping of school records also is important. Tests from time to time give incentive and guidance to the teacher inasmuch as he acquires an estimate of the capacity of his students. To the student, the test also acts as an incentive and furnishes knowledge of his standing and achievement. The benefits obtained, however, are proportional to the accuracy of the evaluation. The evaluation should be based on the actual objective achievement.

A great deal of difficulty is introduced by various subjective features in the grading of students. On the same paper, 118 teachers of Mathematics have given marks which ranged from 28 to 93. To avoid the subjective elements, the objective types of examination may be employed for routine use.

There are five objective types of examination, viz:

(1) One word answer type. (This has the highest correlation factor.)
(2) Multichoice type.
(3) True-false type. (This gives widest range. Graded by rights minus wrongs.)
(4) The completion type.
(5) The cue word type. (Capable of comprehensive, searching examination.)

The first three of these types can be given orally. These objective tests are designed to supplement the older essay type, or longer examinations, with which all instructors are familiar. These newer types of examination have been found to be valid and reliable.

In the last discussion, it was pointed out that our colleges deal, on the whole, with superior intellectual ability but more rigorous selection is necessary. Individuals differ greatly in various traits: intellectual capacity (or cleverness, *i.e.* ability to meet new situations); retentivity; interest; and "driving" power. Individuals who are good in one direction tend, as a rule, to be good in another. Students should be trained to do first-class independent work, and should not be "spoonfed." A consideration of the European "Honors and Pass" system shows the intrinsic merit of this system in producing independent workers. In America, the Iowa System of dividing the class into ranking sections has been productive of good results. It is a desideratum for our colleges to adopt some system that will produce highly trained independent workers. The establishment of fellowships of greater value than those now given would be a step in this direction. The recognition and reward by the community of scholarship and high intellectual effort will make much more effective the attempt on the part of the college to increase the achievement of the student body.

COLORADO INAUGURATES A SUMMER SURVEYING CAMP.

BY HERBERT J. GILKEY,

Assistant Professor of Civil Engineering, University of Colorado.

Until recent years, Civil Engineer and Surveyor have been, in the popular mind, synonymous terms. The surveyor and his transit had all the appeal of romance and mystery. They were the forerunners of empire. There is no doubt that many Civil Engineers were attracted to the calling because they had as boys seen surveyors at work, and decided that they also would "like to do that." Modern education and conditions are doing much to destroy the romantic fascination that has attached itself to surveying. On the other hand, another modern development, the summer surveying camp, tends to restore the appeal that is rapidly being lost. Furthermore it furnishes two other desirable features: continuity of work and freedom from distraction. For these reasons, the University of Colorado is this summer to conduct, for the first time, a surveying camp in the mountains near Boulder. The headquarters will be at Science Lodge near University Camp.

Attendance will be optional. The University has taught and will continue to teach surveying courses on the campus during the summer quarter as well as during the college year. The camp is to meet the needs of those who prefer to take the surveying courses or some portion of them in that way. It will be open to college students and high school graduates, and the requirements for college credit, as regards prerequisites, etc., will be identical with the campus-given courses. In some cases it will be possible for students who have not had the prerequisite trigonometry to take courses but not for college credit. Courses in plane surveying, railroad curves, surveying and mapping, and topographic surveying are offered.

The period of the camp is from June 16 to July 23. For

a fixed sum, the University will furnish transportation, food, shelter, and cots. The students have to bring only bed clothes and personal articles, including text books and drawing instruments, but not drawing boards, T-squares, or supplies.

The site of the camp is unique and typical of Colorado. Located 28 miles from Boulder in Sec. 23, T. 1, N., R. 73 W., in the Colorado National Forest, only 9 miles from the southern boundary of the Rocky Mountain National Park and 6 miles east of the Continental Divide, it is in the midst of a section noted for beauty, grandeur, and scenic interest. Snow capped peaks, mountain lakes and streams, heavy timber, and abundant flora mark the region as possessing features most alluring. The altitude is 9,500 feet. The territory embraced is included in the Rockey Mountain National Park sheet of the U. S. Geological Survey.

University Camp has itself been in operation for several years. Science Lodge, the large building shown in the picture, has been for a number of seasons the headquarters for parties of scientists, notably geologists, who devote several weeks each summer to a study of the surrounding region. It will serve as class room, mess hall, and dormitory to some extent. There are also floored tents.

The atmosphere of the camp is to be one of business and hard work. The instructions will be pursued with vigor for five days a week. Not unmindful, however, that youth seeks conquest by brawn as well as brain, it is proposed to keep the week ends free from collegiate duties in order that the time may be available for making one- and two-day pilgrimages to mountain tops, glaciers, and other points of interest, if desired.

It is believed that the new institution will not only strike a popular need, but that it will be a step forward in engineering education in Colorado. Since the mountains are as rugged and the people are as scarce as in the days of old, this region is indeed a fitting laboratory in which to teach surveying under auspices similar to those which made the profession fascinating to the engineers of former days.

THE ENGLISH DEPARTMENT.

Following the meeting of deans and administrative officers at the University of Michigan, the English Committee through its Chairman sent out to all deans not present at that conference the two communications which were submitted. The purpose of the Committee was to get, if possible, definite information from every engineering or technical school in this country regarding the way in which instruction in English was provided for its students. Such information, it was felt, would be of great value not only to the Committee but to Mr. Wickenden in his survey of the general situation in the field of engineering education. Something more than one hundred letters were sent. The response to the appeal for information has been so prompt, and the letters received have been not only so adequate for our immediate purpose, but so full of constructive suggestions that the Committee feels encouraged to look forward to the Conference on English at the Boulder meeting as a great occasion. There will be, as usual, two sessions of the English Conference, one intended specially to give the teachers of English an opportunity to exchange ideas and discuss common problems, and one at which all who are vitally concerned regarding the training of our engineering students in English,—deans, heads of technical departments, and teachers in engineering subjects, may give us teachers of English their criticisms and suggestions for the betterment of our work. It cannot, at this early date, be definitely announced, but it is possible that the Program Committee may plan a joint conference of the Division of Deans and Administrative Officers and the Committee on English. The universal concern of deans and administrative officers regarding the training of their students in English would certainly presage an interesting session. As for the English Committee, we are agreed, that, since our deans not only best understand what their students need,

but are in a position to get it for them, we should profit by a frank discussion by them of this problem of the students' English.

All deans should urge the teachers giving instruction in English in their schools to come to the English Conference at Boulder. The Committee hopes for a large, enthusiastic body of teachers from the western schools. Just the mere opportunity for getting together and feeling that we are all working at a big, vital problem in the development of engineering education makes these conferences well worth while. They are certainly full of inspiration for us all. And naturally they are a great deal more. I am sure we all go back to our little corners, more serious and more intelligent for the discussion of our mutual problems. If any dean has a group of teachers whose interest is luke-warm or whose vision of the inspiring opportunity afforded by the teaching of English to engineering students is not quite clear, he would do well to send a representative member of the group to our Boulder Conference.

Suggestions for the Conference on English will be very welcome. Address J. Raleigh Nelson, 927 Forest Ave., Ann Arbor, Michigan.

DISCUSSION OF THE PROGRESS REPORT OF COMMITTEE NUMBER 20 ON THE STANDARDIZATION OF TECHNICAL NOMENCLATURE.

BY EDGAR MACNAUGHTON,

Professor of Mechanical Engineering, Tufts College.

The reprinted report of the Committee on the Standardization of technical Nomenclature once more brings to the attention of the members of this Society a weak link in the chain of our educational work—namely, the lack of uniformity in the symbols used by various authors of textbooks to represent the same quantities.

During the past few years more and more emphasis has been placed upon increased efficiency. Our Engineering Societies and managers of manufacturing plants have been standardizing tools and methods in order that work may be done with smaller expenditure of time and labor, and with a consequent increase in the quality and quantity of the product.

Following the same line of reasoning, our Engineering Colleges are endeavoring to increase the quality, at least, if not the quantity of their product. It is, however, being attempted without standardized tools (symbols) with which to work. Standardization of symbols would so economize the time of the student and so increase the ease with which he could turn from one text-book to another that the quantity of work would unquestionably be increased. For instance, a student in Mechanics is taught one set of symbols to represent the stress and section modulus of a beam, and perhaps the next year has a course in Machine Design in which he has to learn another set of symbols to represent these same quantities. This is manifestly a waste of time.

As suggested in the report, the National Engineering Societies have had this question under consideration for some time. It seems, however, as though this Society were the

one primarily interested and if some concrete suggestion regarding standard symbols could be made by our Committee to those in the National Society that the desired goal would be reached more quickly. Each member of our Society, who has some definite ideas regarding standard symbols, should coöperate in this important matter by sending to the Committee any suggestions which he desires to make.

In order to get this matter under discussion, I submit the following symbols as being appropriate for use in texts on heat and steam.

Concept.	Symbol.
Temperature (liquid)	t
" (saturated vapor)	t_v
" (superheated vapor)	t_s
" (absolute)	T
Pressure (lb. per sq. in.)	p
" (lb. per sq. ft.)	P
Volume (liquid)	σ (sigma)
" (saturated vapor)	v
" (superheated vapor)	v_s
Entropy (liquid)	θ (theta)
" (saturated vapor)	ϕ (phi)
" (superheated vapor)	n
" (vaporization)	L/T
Mechanical equivalent of heat	J
Reciprocal of the mechanical equivalent of heat	A
Dryness	X
Latent heat	$L = H - h$
Internal latent heat	ρ (rho)
Heat equivalent of external work	$144\ Apu$ or APu
Ratio of specific heats	γ (gamma)
Specific heat at constant volume	c_v
Specific heat at constant pressure	c_p
Intrinsic energy	I_e
Density (liquid)	$1/\sigma$
" (saturated vapor)	$1/v$
" (superheated vapor)	$1/v_s$
Specific heat of superheated vapor	C_p
Gas equation constant	R
Internal energy	E

The symbols given above are in accord with those given in the Progress Report of Committee Number 20. Minor changes having been made with the purpose of avoiding confusion, as for instance, the heat content of superheated steam as given in the report is H′ whereas H_s seems much clearer and more in accord with present usage. The writer hopes that this discussion will be the forerunner of many on this important question.

COLLEGE NOTES.

The Pennsylvania State College.—The School of Engineering has recently made a number of changes in its curriculum. The number of credit hours in the normal curriculum has been decreased from 20 to 18, not including Military Drill and Physicial Education.

The value of the credit has been increased so that the amount of work required will not be lessened, but the number of hours of perscribed work will be reduced about two or three hours per week.

Heretofore, two years of modern language have been required, and the new curriculum requires only one year, a total of 8 credit hours, where heretofore, there have been 12 credit hours.

There will be two years of English, totalling 10 credit hours; two years of mathematics, totalling 16 credit hours; and two years of economics, business law and political government.

The above is required in all courses.

A separate curriculum in Architecture was established a year ago by action of the Board of Trustees, in addition to the one in Architectural Engineering.

There will be opportunities for Graduate Assistants in the Departments of Architectural, Civil, Electrical, Industrial and Mechanical Engineering, next year. This is an opportunity for graduate study, where the assistant devotes half time to instruction in the laboratories and carries on graduate work or research during the other half.

The salary is $800 for the year of nine months.

Application should be made to the Dean of Engineering.

University of Pittsburgh.—As a link in its chain of extension of educational opportunities to the public at large, the University, by arrangement with KDKA, broadcasting station

of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has established its own sub-station on the campus, and will broadcast educational programs twice a week, beginning Monday evening, March 31.

The Westinghouse Company has installed and will maintain the technical equipment, while the University, with a full-time radio manager, will provide the programs, largely from its own faculty and student body.

The University will broadcast two popular lecture courses —one on "Political Parties" by members of the history and political science faculties, and one on "The Contemporary Novel" by professors of the English department. The fiction course will consist of a lecture each week for ten weeks. The politics course will lead up to and interpret in a scientific non-partisan way, the national Republican and Democratic conventions in June. Other courses will be announced later.

The talks will average fifteen minutes in length and will not be technical or academic. Printed leaflets giving the outlines of the courses, questions for study and reading lists will be distributed at a nominal cost to radio fans who wish to follow the subjects in detail.

Purdue University.—The Construction of the first of four units of the new building for the School of Electrical Engineering, was well under way when the corner stone was laid Thursday, January 24, of this year. The new building is the first of the engineering group to be started on the north campus, in accordance with the plan of the new administration of Purdue University to provide for the needs of the four engineering schools in which 1,900 students are registered.

Although plans have been prepared for the ultimate structure, which will include a building 180 by 220 feet, three stories high, the first unit now under construction will house only the new electrical laboratory and lecture room. This main laboratory, which will include the track and pit for

the Purdue University Interurban Test Car, is 60 by 163 feet in floor plan with a mezzanine balcony, 13 feet in width, extending the entire length of the room. This balcony will be used as a computation room for laboratory tests. Instrument and calibration rooms are provided under the balcony.

Power is to be supplied from the new University power station at 2300 volts, three phase, to sub-station equipment located in a central area in the main laboratory. Alternating current at 110 and 220 volts, as well as direct current at 125 and 250 volts, will be made available at 46 motor blocks and floor test positions by means of a main switchboard and six auxiliary distribution switchboards located at convenient centers of distribution throughout the laboratory. A ten ton crane, which serves the entire laboratory, will operate also in the high voltage laboratory to be located at the end of the machine laboratory when the next unit is added to the building.

The lecture room, which will seat 480 students, is provided with a moving-picture booth and demonstration circuits connected with the laboratory switchboard. Steam heat is furnished from the power station and adequate artificial ventilation is supplied by means of motor driven fans located in a fan-room provided under the lecture room floor.

The unit now under construction represents a cost of $108,000, while the ultimate structure is estimated to cost $400,000. It will be possible to move the greater part of the laboratory equipment to the new building next summer, thereby relieving the fire hazard in the old building which was constructed in 1889. The offices, recitation and design rooms and some of the auxiliary laboratories will necessarily have to be used in the old building for the present. The construction of the second unit will, however, permit the transfer of practically all of the activities of the school to the new location.

SECTIONS AND BRANCHES.

Case School of Applied Science Branch.—A meeting of this branch of the society was held on Febuary 19, 1924. Dinner was served in the Case Club at 6:30 P.M.

Professor Thompson, president of the branch, presided at the meeting which followed. After the routine business had been transacted, C. F. Thwing, president-emeritus of Western Reserve University, gave an address on "Charles W. Eliot, Ex-president of Harvard University; the qualities which made him a great University Executive and a Great Citizen."

A special meeting of the branch was held in the Physics lecture room at 4 P.M. on Monday, March 3, 1924.

Mr. Wm. E. Wickenden explained the purpose of "The Committee on Investigation and Coördination," the sources from which it expects to gather information, and asked for the coöperation of the college in this important survey of engineering education.

Upon motion of Dean Focke, seconded by Professor Boylston the branch unanimously recommended that Case School of Applied Science coöperate with The Committee on Investigation and Coördination.

ANTHONY JENKINS,
Sec.

The University of Maine Branch is holding monthly meetings this year.

Our first meeting, on October 16th, was intended to arouse enthusiasm and pave the way for definite study of the problems of the engineering teacher. Following the election of officers:

President .....Prof. A. S. Hill
Secretary .....Prof. W. D. Emerson

Third Member of
Executive Committee.....Prof. W. S. Evans

Dean H. S. Boardman reviewed the history of our enginering courses, engineering societies, student branches, engineering experiment stations, etc., and pointed out the tendencies in these lines. Dr. H. M. Ellis, head of the Department of English, spoke about the attitude of English Departments towards Engineering Education, based upon the S. P. E. E. English Conference held at Cornell last June.

Our next meeting was held on November 20. After a brief report on the New England Section Meeting, held at Kingston, R. I., the advisability of a five-year engineering course at the University of Maine was discussed. Prof. B. C. Kent, who had devoted considerable time to the subject, was unable to be present and his outline was read. This lead to a vote expressing approval of optional curricula for five-year engineering courses, the first two years to consist of general study in the College of Arts and Sciences, followed by three years of professional engineering study in the College of Technology; and a request asking the Faculty of the College of Technology to appoint a committee to provide such curricula. Professor Kent has consented to study the matter further as a Branch Activity. We hope to have another discussion on this subject before the end of the year.

Our last meeting, on January 15, was devoted to Methods of Teaching. Discussion was opened by Mr. E. W. Davee with an outline of methods of teaching shopwork. This was followed by Mr. R. E. Downing on methods of teaching laboratory. Prof. H. W. Leavitt gave a very interesting and instructive talk on class-room methods. Methods outlined were as follows: (1) Study Lesson, (2) Report Lesson, (3) Coöperative Recitation, (4) Textbook, (5) Lecture, special attention being called to an article in the December, 1922, Bulletin by Prof. W. R. Veazey. No definite conclusion was reached but many new ideas on an old subject were expressed.

We plan to follow this with a discussion on the real training and functions of the engineering teacher.

In all of these discussions frequent mention is made of statements in past Bulletins of the Society and in the Dr. C. R. Mann Report.

W. D. EMERSON,
Secretary.

The **Minnesota Section** of the Society for the Promotion of Engineering Education held the third meeting of the year in Room 201 Men's Union on Wednesday, February 27, 1924. Professor J. I. Parcel, of the Civil Engineering Department, and Professor W. E. Brooke, of the Department of Mathematics and Mechanics, were the chief speakers of the evening. Professor Parcel talked upon "What Should Be Done For The Good Student" and Professor Brooke's subject was "What Should be Done For the Poor Student." That these subjects were of more than ordinary interest may be inferred from the fact that the discussion which followed exceeded the length of time usually allowed by an hour. The meeting adjourned at 9:00 o'clock.

H. B. WILCOX,
Secretary.

The **Pittsburgh Section** of the Society held its mid-winter meeting at the Faculty Club of the University of Pittsburgh on February 9, 1924. The meeting was called to order at 4:00 P.M., by J. H. James, Carnegie Institute of Technology, *Chairman,* who introduced Mr. W. E. Wickenden, Director of Investigations of the Society. Mr. Wickenden gave a brief resume of the work of the Board of Investigation and Coördination and emphasized the need of coöperation of the engineering schools. In speaking of the students, Mr. Wickenden said we know far too little about the selection on the basis of aptitude for the engineering course; the choice of a course in engineering after he has been admitted; what happens to him after graduation; how are the engineering gradu-

ates distributed; engineering education cannot be completed in college; what part must be given in the college and what part in active industrial life which follows after graduation; what responsibility has the college beyond the day of graduation; has the college a function to perform in that period; what are the special elements of preparation which the student needs to establish him in these early years of professional life; what are the circumstances that surround the engineer in his mature life; the engineer begins with physics or chemistry at one end and goes on until it reaches the business man at the other end. He also spoke of the co-operation of the committees in the colleges, of the committees of the Society, and the joint advisory councilors appointed by the National Engineering Societies.

After dinner, Morris Knowles, Consulting Engineer, spoke on Engineering Education Investigations from the Standpoint of the Professional Engineer, W. E. Mott, Director, College of Engineering, Carnegie Institute of Technology discussed it from the standpoint of the engineering schools; John G. Bowman, Chancellor, University of Pittsburgh, talked on the Similarity Between Medical and Engineering Educational Investigations. Discussion followed.

The next meeting will be the spring meeting called to discuss A General Course in English for Freshmen; the Teaching of English to Upper Classes of Engineering Students; and English from the Standpoint of Business.

J. H. JAMES,
Chairman.
L. C. MCCANDLISS,
Secretary.

The **Purdue Branch** held its second meeting of the school year Friday evening, March 7, at the Lahr Hotel. Forty-three members and guests gathered for a 6:30 o'clock dinner. Professor S. D. Chambers, Chairman of the branch, presided.

The address of the evening was given by W. E. Wickenden, Director of Investigations for the S. P. E. E. Mr. Wicken-

den pointed out the fact that the present extensive investigation in which so many are interested came from within the body of engineering teachers and not from without as is the case with so many investigations.

After the address Mr. Pfeif of the General Electric Company, who was also present, made some pertinent remarks dealing with his experiences in directing engineering students.

A general discussion followed, the principal speakers being Dean A. A. Potter, Professors W. K. Hatt, C. F. Harding, G. L. Roberts, G. H. Shepard, D. D. Ewing, A. C. Staley, E. L. Erikson and O. A. Greiner.

JOHN A. NEEDY,
Secretary.

SOCIETY NOTES.

Dean Anson Marston, of the Iowa State College, has been appointed the representative of this Society on the Advisory Council of the American Engineering Council to coöperate in the movement for the establishment of Public Works Department in the national government.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

The Annual Meeting of the British Association for the Advancement of Science will take place this year in Toronto from August 6 to 13 inclusive, under the Presidency of Major-General Sir David Bruce, K.C.B., F.R.S. The meeting will be attended by leading scientific men and women from Great Britain and elsewhere, and there is a general and intense desire on their part that the occasion should afford opportunity for personal contact with their colleagues in science in North America.

INTERNATIONAL MATHEMATICAL CONGRESS.

The International Mathematical Congress will be held at Toronto, Canada, August 11th to 16th, 1924, under the auspices of the Royal Canadian Institute and the University of Toronto.

This is the first meeting of the Congress to be held on the American Continent. It is hoped therefore, that it will be largely attended by American Mathematicians, mathematical physicists and engineers. Special prominence will be given to engineering applications of mathematics, and contributions are invited from mathematical physicists and engineers engaged in mathematical investigations of engineering problems.

It is hoped that it may be possible to print the proceedings of the Congress, and that they may form a complete contemporary account of the pure and applied mathematical sciences.

Abstracts of papers should be addressed to Prof. J. L. Synge, Secretary, Royal Canadian Institute, Toronto, Canada, and should be in his hands before the opening of the Congress.

The Congress will meet in the following sections:

Section I: Algebra, Theory of Numbers, Analysis.
Section II: Geometry.
Section III: (a) Mechanics, Mathematical Physics.
(b) Astronomy, Geophysics.
Section IV: (a) Electrical, Mechanical, Civil and Mining Engineering.
(b) Aeronautics, Naval Architecture, Ballistics, Radiotelegraphy.
Section V: Statistics, Actuarial Science, Economics.
Section VI: History, Philosophy, Didactics.

The above arrangement of Sections is designed to afford in the sphere of Applied Mathematics full opportunity for consideration not only of those questions in which interest is purely scientific, but also of practical problems of engineering the solution of which contributes directly to the cause of material progress.

The British Association for the Advancement of Science will hold its Annual Meeting in Toronto from August 6 to August 13, 1924.

Additional information may be obtained from Prof. J. L. Synge, Royal Canadian Institute, Toronto, Canada.